Preliminary investigations of deposits

1. INTRODUCTION

In the desk study, the regional geology is depicted and some potential areas are selected for further investigations. All information obtained so far, has been collected from available published documents and maps. During the following step, known as preliminary field investigations, the geologist is confronted with geological features and problems as found in the field. The geologist will describe the nature, disposition and the structure of the rock exposures of the selected areas in order to gain a first impression of the quality and reserves of several **potential** sites.

The preliminary investigations are the highest risk stage in exploration. For this reason, the geological knowledge, experience and the skills of the observer are of paramount importance to ensure a sound basis for further work. The preliminary investigations must therefore have the lowest unit cost ($ / per square km). If the results are negative, the whole project has to be stopped and similar investigations will have to be conducted in other regions or areas. Positive results call for further, thorough investigations in the promising areas. In any case, after the completion of this step, the client should be in a position to decide on whether or not further investigations should be carried out.

The first of the so-called GO / NO GO decisions.

2. GEOGRAPHICAL SITUATION OF THE DEPOSITS

In this first reconnaissance, the morphology of the areas under consideration will be described in order to show a real picture about

- Transportation infrastructure
- Potential plant site
- Climate
- Morphology of the deposit
- Quarrying possibility
- Environment

3. GEOLOGICAL SITUATION OF THE DEPOSITS

The exposures are described according to lithology, colour, mineralogy, fossil and microfossils. Each outcrop is recorded on a map (sketch or good draft) of the area drawn by the geologist. The structure of the rocks, for instance dip and strike, are measured and recorded on the map.

The aim is to show

- the distribution of the different lithologies of the deposit under consideration
- to calculate the inferred reserves and
- to make a preliminary qualitative determination based on surface sampling.

Further on in this chapter, we will to discuss the quality of the raw materials and the problems associated with sampling procedures

4. SAMPLING

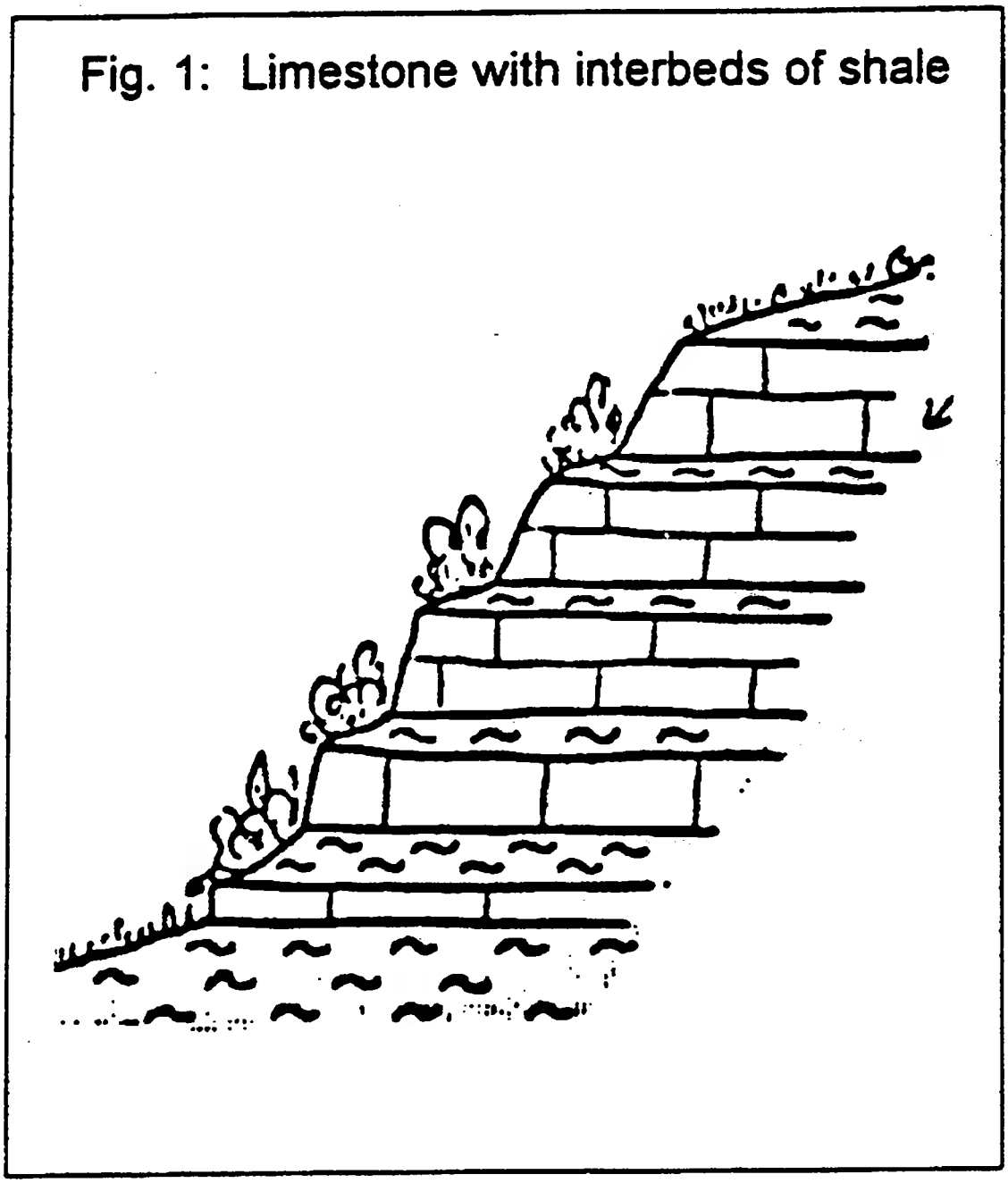
In the preliminary investigations, the quality of the raw materials is determined by surface sampling only. These samples provide an initial, tentative assessment of the quality of the deposit being investigated. The geologist establishes a sampling programme with due consideration of the geological situation, time and finances available. The sampling locations and the methods should be chosen in order to provide maximum information.

Surface sampling is a delicate task, which requires skill.

Sampling should be **representative** of the exposure.

For example, the exposure in Fig.1 shows alternating thick layers of limestone and shale. Vegetation covers the interbeds of shale. A poor sampling process, in which only the exposed layers of limestone are sampled, will give an incorrect image of the chemical character of the outcrop. The titration value of the limestone layers amounts to 90%. However, the real titration value of the total outcrop (including the interbeds of shale) is only 72 %.

Fig.1 Limestone with interbeds of shale



4.1 Sampling methods

Surface sampling can be carried out in different ways depending on :

- homogeneity
- hardness of the rocks

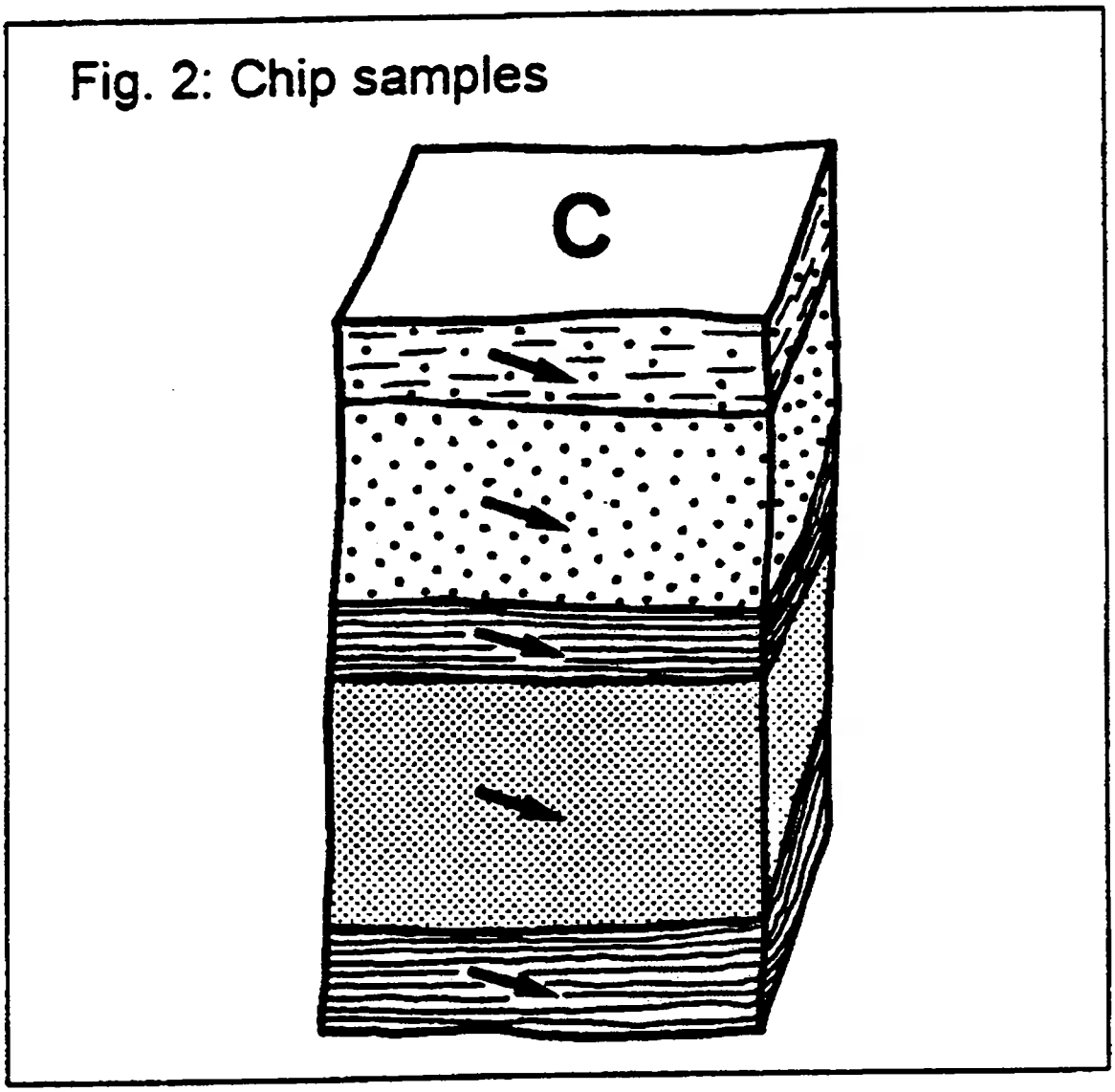
Sampling must be carried out perpendicular to the stratification.

4.1.1 Homogeneous and hard rocks

Chip samples

One sample, which is considered as representative, is taken from every horizon (strata) or from available exposures.

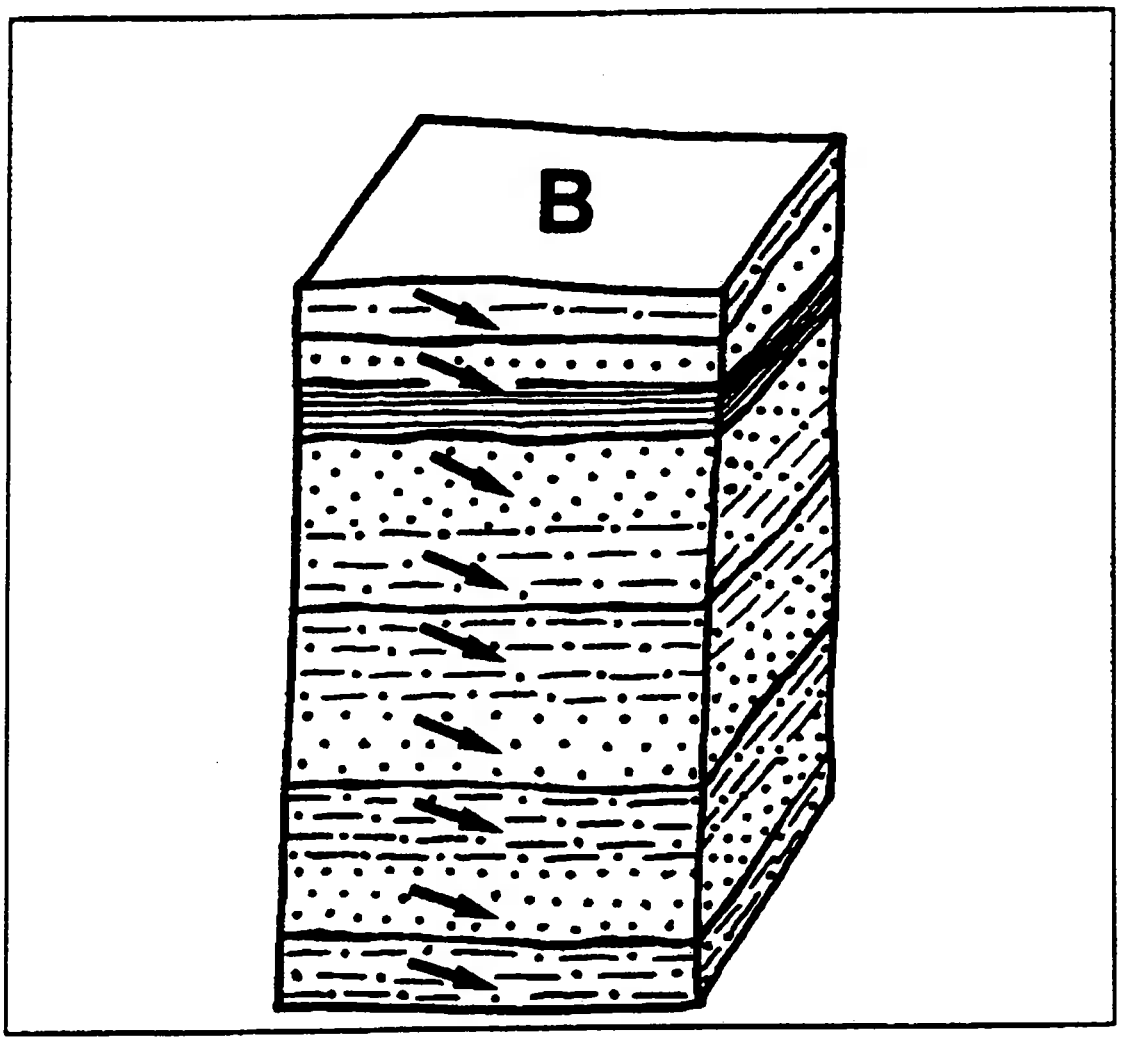
Fig. 2 Chip samples



Composite chip samples

The same quantity of chip material is taken at a constant interval. All chip samples from one exposure are placed in a bag which is representative of a given thickness or composite horizon. A good knowledge of the quality of the exposure is obtained.

Fig. 3 Composite chip samples



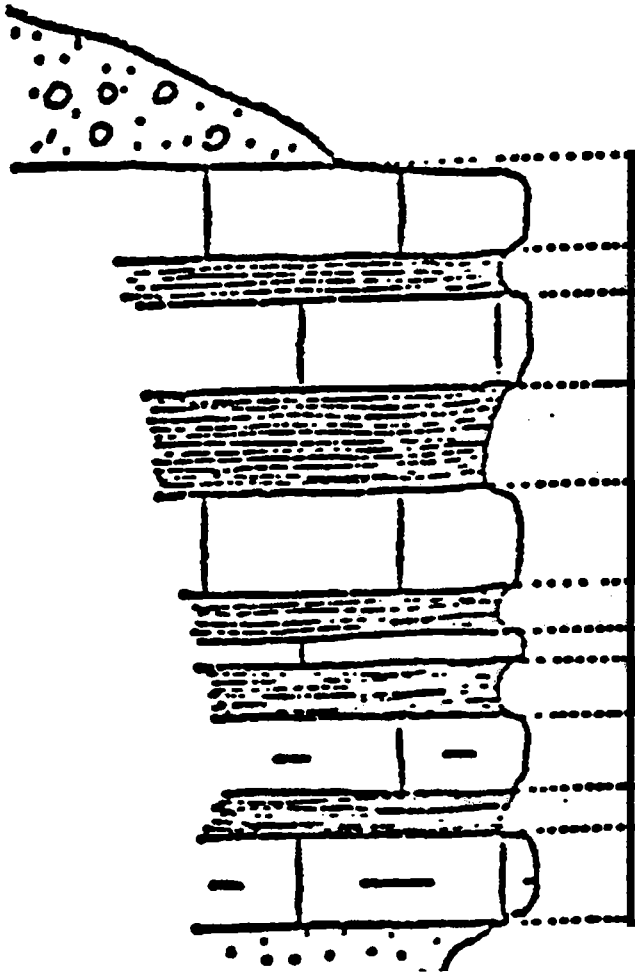
4.1.2 Heterogeneous and hard rocks

Pondered composite sample

Every layer will be sampled. The quantity of materials is dependent on the true thickness of the strata.

The chemical composition of the exposure is well defined.

Fig. 4 **Pondered composite samples**



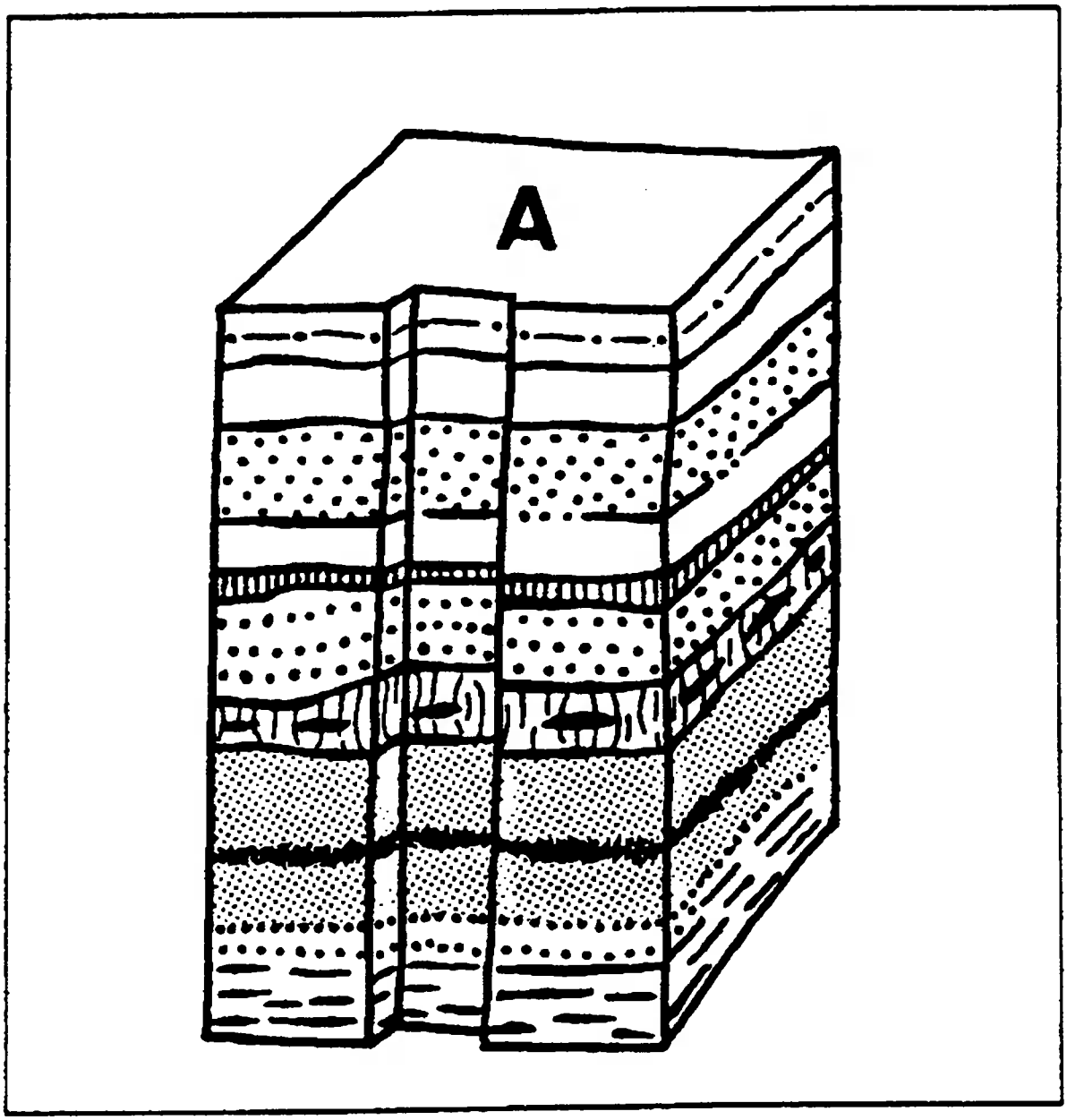
Thickness	Proportion in the mix
1.20	3
0.60	1,5
1.40	3,5
2.00	5
1.40	3,5
0.80	2
0.40	1
1.00	2,5
1.20	3
0.40	1
1.60	4

4.1.3 Heterogeneous and soft rocks

Channel sampling

The sample is collected along a continuous channel cut at right angles to the stratification. That is the best method to obtain an accurate chemical composition of the whole exposure.

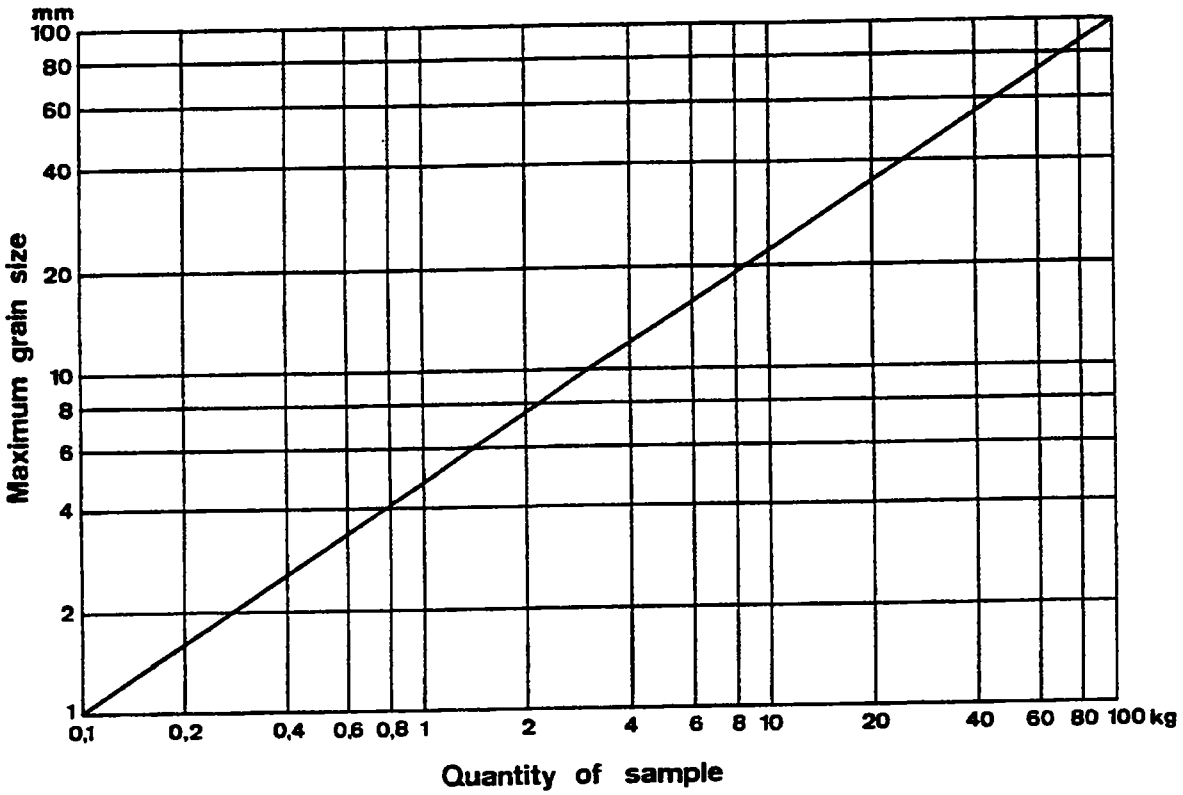
Fig. 5 Channel samples



4.2 Quantity of materials

To obtain a representative sample, the quantity of material to sample depends on the granulometry of the material. Fig. 6 shows the relation between maximum grain size and the sample quantity.

Fig. 6 Maximum grain size versus sample quantity



In some cases, the sample quantity is also determined the testing programme to be carried out. Experience has shown that the following quantities of cement raw materials are necessary for laboratory tests conforming to HMC standards (Table 1).

Table 1 Sample quantity for various tests

Test	Required Quantity
Chemical analysis Mineralogival analysis Physical properties	1 - 2 kg per component or fist-sized specimens, eventually
Water Analysis	1 litre
Fuel	1 kg, resp. 1 litre
Compressive strength	30 x 30 x 40 cm block
Crushing properties	blocks of > 20 cm length or edges
Grindability properties	10 - 20 kg
Lime burning	10 x 10 x 10 cm block
Slurry properties	1 litre
Filtration test	50 - 150 kg

Normally, not only one but also a combination of tests is conducted on the same sample. 1 to 2 kg of raw material component is sufficient to yield results on chemical and mineralogical compositions, for examinations on granulation and burnability properties, to determine physical parameters such as moisture content, porosity, density, water absorbtion etc.

5. QUALITY OF THE RAW MATERIALS

The quality of the raw materials can be appraised by

- geological description of the outcrops
- testing for chemical and thechnical parametrs

For all the types of raw materials, the following geological description of the exposure will be done:

- type of rocks, mineral content
- diagenitic process
- granulometry
- colour
- fossil content
- type of porosity
- structure:
  dip and strike of the layers; thickness of the layers laminations; joints, density of joints, length; faults and folding.

The macroscopic features control the physical and mechanical properties of the rocks. For instance, the hardness of the rock depends on the type of diagenesis and porosity; the shape of the crushed rocks depends on the anisotropy of the rocks (fine stratification, lamination, foliation).

5.1 Quality of raw materials for cement manufacturing

In the preliminary investigations, the raw materials are appraised by the chemical analyses of the surface samples and by the general features of the rocks at the outcrops.

We want here to focus our attention on few components which could be deleterious for the clinker production. A complete assessment of the raw materials quality parameters is shown in chapter 6.

The table 2 depicts the most frequent deleterious constituents containing in the raw materials

Table 2 Maximum permitted levels of deleterious elements in the raw meal

Constituents	Max % in Raw Meal (LOI free basis)	Remarks
MgO	< 5 % (abs. max. 6 %)	MgO come mainly from the calcareous component
SO_3	< 1 %	In general, SO_3 comes from the argillaceous-siliceous component
K_2O Na_2O Na equivalent Low alkali	< 1.4 % < 0.8 % < 1.2 % < 0.6 %	Argillaceous-siliceous components contain the alkalis
Cl^-	< 0.02 %	All components can have high Cl^- content

From a physical point of view, the outcrops are investigated in order to determine the following features:

- Homogeneity of the deposit (interbeds, horizontal or vertical variation in lithology,...)
- Presence of chert, i.e. cryptocristalline quartz, occurring as nodules, lenses in limestone and shales
- Proportion of abrasive minerals (quartz grains)

All these parameters are significant to assess the suitability of a deposit. Heterogeneous deposits will require selected quarrying.

5.2 Quality of pozzolanas

Pozzolana is a siliceous or siliceous - aluminuous material which in itself possesses little or no cemtitious properties. Finely ground and in presence of moisture (water), the material reacts chemically with calcium hydroxide, Ca $(OH)_2$ at at ambient temperature to form compounds possessing cementitious properties (calcium silicate and calcium aluminate minerals).

The natural pozzolanas are mostly volcanic products such as ashes, tuffs (consolidated ashes) and lavas. Other well-known natural types are diatomaceous earth, and opaline shales.

The quality of pozzolanas can only be appraised by testing of samples. The following properties of the pozzolanas should be considered in the testing programme:

- Petrography: description of the texture and the mineral composition
- Chemical composition
- Mineralogical composition: Proportion of amorphous, glassy material or content of zeolithes by X ray diffraction
- Hydraulic index: Keil index
- Pozzolanic activity. Holderbank norm follows the ASTM C-311-90 standard.

Selection of suitable deposits should take place based on the tests results of several representative samples.

Once selected, a grindability test should be carried out on the deposit.

5.3 Quality of aggregates

The outcrops have to be carefully described as mentioned under paragraph 5. However, several tests must be carried out on representative samples.

- Physical tests:
  - density
  - porosity
  - surface texture of crushed material
  - shape of the crushed material
  - proportion of dust/ fine material
- Mechanical tests
  - compressive uniaxial strength
- Chemical analysis
  - Cl content
  - Alkali-silica reaction
  - Alkali-carbonate reaction
  - Organic content